PATENT SPECIFICATION

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PROVISIONAL SPECIFICATION

Improvements in or relating to Processes and Apparatus for Drying Granular or Powdered Materials

We, GEORGE WILLIAM RILEY, a British Subject, and GEORGE SCOTT & SON (LONDON) LIMITED, a British Company, both of Artillery House, Artillery Row, London, S.W.1, do hereby declare the nature of this invention to be as follows:—

This invention relates to processes and apparatus for drying granular or powdered materials by heat treatment *in vacuo*. The invention relates, for example, to processes and apparatus for the vacuum drying to a predetermined moisture content of cereal grain. It is not limited to this particular application of it however, but is broadly applicable to the drying of any granular or powdered material.

The object of the invention is to provide an improved process and corresponding apparatus which will be highly efficient, easy to operate and largely automatic.

According to the invention, a process of drying granular or powdered materials by heat treatment thereof *in vacuo* consists in continuously feeding the material through a heated first-stage vacuum drier and batch-wise and while the partially dried material is still hot, completing the drying of the material to the predetermined extent in a second-stage vacuum drier in which a higher vacuum is maintained than in the first-stage drier and which is unheated so that simultaneously with the completion of drying of the material the latter becomes cooled to a suitable temperature for discharge from the drier.

By the present invention therefore, a process is provided in which material is heat-dried *in vacuo* continuously and delivered upon completion of drying to the predetermined extent required in cooled condition.

The invention comprises both the improved process of vacuum drying and cooling and also apparatus for carrying the process into effect.

According to one convenient and preferred form of such apparatus, the first-stage vacuum drier is of vertically disposed multi-tubular form. Thus, the drier comprises a series of vertically disposed tubes around which steam is circulated at a controlled temperature according to the desired or requisite operative temperature of the drier. The grain or the like gravitates down these tubes, the interiors of which are maintained under a controlled degree of vacuum. Above the tubes is a reception hopper for the grain or the like and below the tubes a collection hopper. These two hoppers are in open communication with the interior of the tubes so as to be under the same degree of vacuum therewith. The grain or the like is fed into the reception hopper by way of a vacuum feeding device of any convenient form. Instances of suitable forms will be described hereinafter.

The collection hopper below the tubes of the drier is preferably of downwardly tapered form at the bottom and terminates at the bottom of the taper in a delivery outlet for the partially dried grain or the like, this outlet being controlled by an hermetically tight valve which is normally open, that is, during the feed of the material through the drier, so as to permit the flow of the partially dried material into the second-stage drier below, but is periodically closed, as hereinafter described, during the operation of the second-stage drier.

The second-stage drier comprises a vertically disposed tubular chamber the lower part of which is of downwardly tapered form and is fitted at the bottom of the taper with a discharge outlet for the fully dried and cooled material, this outlet being controlled by an hermetically tight valve, which is periodically opened to permit the discharge of the fully dried material.

The second-stage drier is unheated and upon becoming filled to the required extent with partially dried material from the first-stage drier, is isolated therefrom by closure of the valve between the two driers, whereafter a somewhat higher degree of vacuum is built up in it than the vacuum normally maintained in the apparatus, with the result that the

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material which has passed into the second-stage drier and which is still hot from the heat imparted to it in the first-stage drier, becomes further dried and at the same time cooled by the cooling effect of evaporation. In the result, therefore, the fully dried material, upon discharge from the second-stage drier, is in a cooled condition.

The continuous traverse or gravitation of the grain or the like down the tubes of the first-stage drier, may be controlled or regulated by any convenient means, for example, an oscillating or revolving plate disposed in a horizontal plane immediately below the outlets or lower ends of the tubes.

If desired, moreover, in order to ensure uniformity of treatment of the grain or the like throughout the columns thereof descending the tubes, each tube may be fitted with a core or interior member of such a form as in effect to guide the individual grains or the like first towards the heated surface of the tube and then away therefrom, in this way ensuring that all of the individual grains of the column shall receive substantially the same amount of heat from the surface of the tube, or in other words, that an approximately uniform average temperature shall be obtained completely across the section of the descending column of material.

Referring again to the vacuum feeding device by way of which the grain or the like is fed into the reception hopper of the first-stage drier, one convenient form of such device comprises a pair of rubber rolls disposed tangentially to one another in accordance with the arrangement described in the Specification of Patent No. 377,502.

Alternatively, a rotary disc or plug valve with pockets alternately in communication with the atmosphere and the reception hopper of the drier may be employed.

Or again, a hopper could be used which is interposed between the reception hopper of the drier and a supply hopper proper and constitutes in effect a vacuum lock between these two hoppers, the interposed hopper being arranged to be placed in open communication with the supply hopper proper and cut off or isolated from the reception hopper of the drier during the operation of filling the interposed hopper and *vice versa* during the operation of emptying it, that is, into the reception hopper of the drier. For this purpose, hermetically tight valves would be provided in the respective discharge outlets of the two hoppers.

Or, in further alternative, the following method could be employed, according to which the grain or the like is conveyed into the vacuum system in a stream of water. The material is fed at atmospheric pressure into a supply hopper along with sufficient water to enable it to be sucked from the hopper by means of a pump and delivered into a vacuum chamber situated at a level above that of the surface level of the grain or the like in the hopper. In this vacuum chamber surplus water is removed from the material, any convenient means being employed for this purpose, for example, a centrifugal separator or a vibrating sieve. The de-watered material then gravitates from the vacuum chamber through a closed chute or the like into the reception hopper of the drier, while the separated water flows down a barometric leg into the supply hopper, wherein it mixes with a further supply of grain. Alternatively, that is, instead of thus recycling the water back to the vacuum chamber, the separated water from the said chamber may be withdrawn by a pump.

As already stated, a higher degree of vacuum is periodically established in the second-stage drier than that which normally obtains in the apparatus. Any convenient form of means may be employed for providing for this and for maintaining the respective degrees of vacua. According to one convenient arrangement, the vapour which forms in the first-stage drier is led off from the upper part of the reception hopper of the drier to a condenser interposed in the course of the vapours between the drier and a wet vacuum pump. This condenser may conveniently be a barometric contra-flow jet condenser, although a surface condenser may if desired be employed, or any other suitable form of condenser for the purpose. The vapour which forms in the second-stage drier is led off from the upper part therefrom to a second condenser which may conveniently be of the surface type. The uncondensed vapour from this condenser is compressed into the first mentioned condenser by means of a steam jet pump, which operates as will be appreciated, to build up the degree of vacuum in the second mentioned condenser and therefore in the second-stage drier (after this has been isolated from the first-stage drier) to the higher degree of vacuum to obtain in that drier during the completion of drying therein. For example, in the case where the material to be dried is damp grain, the operative vacuum obtaining in the driers while these are in open communication with one another could be say twenty-eight inches with a steam tempera-

ture, say 37.5° C., while the higher vacuum which is periodically built up in the second stage drier would be, say, 29.4 inches. It will be understood, however, that these specific degrees of vacuum are mentioned purely by way of example, and that the actual vacua employed in the operation of the plant will depend upon a variety of factors, including for instance the nature and water content of the material to be dried and the steam temperature employed in the first-stage drier.

To enable the second-stage drier to be opened for the discharge of the fully dried and cooled material, the said drier is or may be provided with an air break cock.

Between the second mentioned condenser and the steam jet pump is a vacuum valve, and a second vacuum valve is provided controlling a passage short-circuiting the jet pump. The second of these valves is opened and the first shut until the wet vacuum pump has built up, say, the 28 inches of vacuum in the driers, whereupon, after closure of the valve between the two driers, the second valve is shut and the first opened to enable the steam jet to build up the higher vacuum in the second-stage drier.

The two valves controlling respectively the delivery of the partially dried material from the first-stage drier to the second-stage drier and the fully dried and cooled material from the second-stage drier to the atmosphere, together with the two vacuum valves referred to, the air break cock and if desired inlet and outlet valves to a feed receiver, may conveniently be operated automatically and in timed sequence through the intermediary of a timing gear designed to permit the cooling and discharge of the material from the apparatus intermittently in a predetermined time cycle in which the intermittent cooling and discharge is in timed correlation to the continuous feed of the material through the tubes of the first-stage drier.

Instead of employing a vertically disposed tubular drier, the first-stage drier of the plant may if desired comprise a horizontally disposed tubular system in which steam circulates through a series of horizontally disposed tubes spaced from one another so as to provide serpentine passages between the tubes down which the grain or the like is caused to gravitate at a controlled rate in contact with the heated walls of the tubes, for example, by means of an oscillating or revolving plate similar in principle of operation to the oscillating or revolving plate of the construction above described, the said plate being provided however, with spouts to assist in the passage of the material past the plate.

It will be understood, with further reference to the manner of operation of the plant, that while completion of the drying of the material is taking place under a higher vacuum in the second-stage drier, feed of the material through the first-stage drier continues and collection of the partially dried material from that drier takes place above the closed valve between the two driers in the collection hopper of the first-stage drier. This collection of partially dried material then descends into the second-stage drier upon opening of the valve between the two driers, whereafter the partially dried material from the first-stage drier flows uninterruptedly through the valve into the second-stage drier until the valve is closed again for the next operation of the second-stage drier.

It will be also understood that the invention is capable of considerable variation as regards constructional details and arrangement of parts of the plant. For example, the first and second stage driers may be of any other convenient form than that described above, as also may the means for providing the requisite degrees of vacuum in the driers and again the means for feeding the material to be dried into the vacuum system. Moreover, instead of employing steam as the heating medium for the driers, hot water or any other convenient heating medium may be employed and either atmospheric or sub-atmospheric pressure may be employed in the event of steam being used.

Dated this 30th day of July, 1936.
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Chartered Patent Agents,
15, South Street, London, E.C.2,
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COMPLETE SPECIFICATION

Improvements in or relating to Processes and Apparatus for Drying Granular or Powdered Materials

We, GEORGE WILLIAM RILEY, a British Subject, and GEORGE SCOTT & SON (LONDON) LIMITED, a British Company, both of Artillery House, Artillery Row, London, S.W.1, do hereby declare the nature of this invention and in what

manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to processes and apparatus for drying granular or powdered materials by heat treatment *in vacuo*. The invention relates, for example, to processes and apparatus for the vacuum drying to a predetermined moisture content of cereal grain. It is not limited to this particular application of it however, but is broadly applicable to the drying of any granular or powdered material.

The object of the invention is to provide an improved process and corresponding apparatus which will be highly efficient, easy to operate and largely automatic.

According to the invention, a process of drying granular or powdered materials by heat treatment thereof *in vacuo*, consists in continuously feeding the material at a controlled rate along the interior of a heated first-stage vacuum drier and out of that drier into an unheated second-stage vacuum drier which during the normal course of the drying process is in open-communication with the first-stage drier and is therefore under the same degree of vacuum thereas, and while continuing the feed of the material along the interior of the first-stage drier, periodically cutting off communication between the two driers and subjecting the partially dried material in the second-stage drier to a higher degree of vacuum than that to which it has been subjected in its passage through the first-stage drier and its discharge therefrom into the second-stage drier, until it has become completely dry and sufficiently cool to enable it to be discharged from the drier, whereupon it is discharged therefrom, the second-stage drier is again placed in open communication with the first-stage drier and progressively filled therefrom with a further batch of partially dried material, while continuing the feed of material along the interior of the first-stage drier, this further batch of material upon completion of drying and cooling is discharged from the drier and the cycle of operations is continuously repeated so long as material is being fed along the first-stage drier.

In this process, therefore, the material is heat-dried *in vacuo* in a continuous manner and delivered upon completion of drying to the predetermined extent required and in batches in cooled condition.

The invention comprises both the improved process of vacuum drying and cooling and also apparatus for carrying the process into effect.

Further according to the invention, therefore, apparatus for carrying the process into effect comprises a first-stage vacuum drier having an inlet for the material to be dried and an outlet for the partially dried material; hermetic means for controlling the said inlet and the said outlet; means in the first-stage drier for effecting or regulating the passage of the material to be dried therethrough, at a controlled rate; an unheated second-stage vacuum drier communicating with the outlet of the first-stage drier and having an outlet for fully dried material; hermetic means for controlling the outlet of the second-stage drier, this means and the hermetic means first referred to being adapted to enable the two driers to be placed into open communication with one another for the through passage of the partially dried material from the first-stage drier to the second-stage drier during the normal course of the drying process and then to be temporarily isolated from one another during the batchwise completion of drying and simultaneous cooling of the partially dried material in the second-stage drier; heating means in the first-stage drier for heating the material therein and vacuum producing means for exhausting the driers, the said vacuum producing means being adapted to maintain a higher degree of vacuum in the second-stage drier than in the first-stage drier and concomitantly therewith.

The invention comprises a number of other features which contribute to the general utility of the process and apparatus according to the invention and which will be pointed out hereinafter and severally claimed.

The invention will now be further and more particularly described with reference to the accompanying drawings, which are largely diagrammatic and which illustrate with certain modifications a preferred embodiment of the invention.

In the drawings,

Figure 1 is a substantially complete view of the apparatus according to this embodiment;

Figure 2 is a partial view thereof showing a modification hereinafter described;

Figure 3 is a further partial view of the said apparatus, showing another modification also hereinafter described, and

Figure 4 is a diagrammatic view of the apparatus drawn on a smaller scale than the previous views and showing a further modification hereinafter described.

Referring to Figure 1, the apparatus there shown comprises a first-stage vacuum drier 1 of vertically disposed

multi-tubular form. This drier comprises a series of vertically disposed tubes 2 around which steam is circulated at a controlled temperatur according to the desired or requisite operative temperature of the drier, the steam space around the tubes being bounded at the top and bottom by end plates 3, 4. The grain or the like gravitates down the tubes 2, the interiors of which are maintained under a controlled degree of vacuum.

Above the tubes is a space 5 for the reception upon its introduction into the drier, of the grain or the like and below the tubes is a second space 6 for the temporary collection within the drier of the partially dried material while the second-stage drier is in operation, as hereinafter described.

The two spaces 5, 6 are in open communication with the interior of the tubes so as to be under the same degree of vacuum therewith.

The grain or the like is fed into the reception space 5 by way of a vacuum feeding device of any convenient form, for example one or other of the specific forms hereinafter referred to.

The collection space 6 is preferably, as shown, of downwardly tapered form at the bottom and terminates at the bottom of the taper in a delivery outlet 7 for the partially dried grain or the like, this outlet being controlled by an hermetically tight valve 8 which is normally open, that is, during the feed of the material through the drier, so as to permit the flow of the partially dried material into the second-stage drier below, but is periodically closed during the operation of the second-stage drier.

The second-stage drier comprises a vertically disposed tubular chamber 9 the lower part of which is of downwardly tapered form and is fitted at the bottom of the taper with a discharge outlet 10 for the fully dried and cooled material, this outlet being controlled by an hermetically tight valve 11, which is periodically opened to permit the discharge of the fully dried material.

The second-stage drier is unheated and upon becoming filled to the required extent with partially dried material from the first-stage drier, is isolated therefrom by closure of the valve 8 between the two driers, whereafter a somewhat higher degree of vacuum is built up in it than the vacuum normally maintained in the apparatus, with the result that the material which has passed into the second-stage drier and which is still hot from the heat imparted to it in the first-stage drier, becomes further dried and at the same time cooled by the cooling effect of evaporation. In the result, therefore, the fully dried material, upon discharge from the second-stage drier, is in a cooled condition.

The continuous traverse or gravitation of the grain or the like down the tubes 2 of the first-stage drier, is controlled or regulated by any convenient means, for example, by an oscillating or revolving plate 12 disposed in a horizontal plane immediately below the outlets or lower ends of the tubes.

If desired, moreover, in order to ensure uniformity of treatment of the grain or the like throughout the columns thereof descending the tubes, each tube may be fitted with a core or interior member 13 of such a form as in effect to guide the individual grains or the like first towards the heated surface of the tube and then away therefrom, in this way ensuring that all of the individual grains of the column shall receive substantially the same amount of heat from the surface of the tube, or in other words, that an approximately uniform average temperature shall be obtained completely across the section of the descending column of material.

Referring again to the vacuum feeding device by way of which the grain or the like is fed into the reception hopper of the first-stage drier, one convenient form of such device comprises a pair of rubber rolls 14 disposed tangentially to one another in accordance with the arrangement described in the Specification of Patent No. 377,502.

Alternatively, a rotary disc or plug valve with pockets alternately in communication with the atmosphere and the reception hopper of the drier, for example such a valve of the construction described in the Specification of Patent No. 12316 of 1900, may be employed.

Or again, as shown in Figure 2 of the accompanying drawings, a feed receiver in the form of a hopper 15 could be used which is interposed between the reception space 5 of the drier and a primary supply hopper 16 and constitutes in effect a vacuum lock between these two parts of the apparatus, the interposed hopper being arranged to be placed in open communication with the primary supply hopper and cut off or isolated from the reception space 5 of the drier during the operation of filling the interposed hopper and *vice versa* during the operation of emptying it, that is, into the reception space of the drier, and hermetically tight valves 17, 18 being provided in the respective discharge outlets of the two hoppers.

Or, in further alternative and as shown in Figure 3, the following method could

be employed, according to which the grain or the like is conveyed into the vacuum system in a stream of water. The material is fed at atmospheric pressure into a supply hopper 19 along with sufficient water to enable it to be sucked from the hopper by means of a pump 20 and delivered into a vacuum chamber 21 situated at a level above that of the surface level of the grain or the like in the hopper 19. In this vacuum chamber surplus water is removed from the material, any convenient means being employed for this purpose, for example, a centrifugal separator or a vibrating sieve (not shown). The de-watered material then gravitates from the vacuum chamber through a closed chute 22 or the like into the reception space 5 of the first-stage drier, while the separated water flows down a barometric leg 23 into the supply hopper 19, wherein it mixes with a further supply of grain. Alternatively, that is, instead of thus recycling the water back to the vacuum chamber, the separated water from the said chamber may be withdrawn by a pump. The interior of the chamber 21 is maintained under the necessary vacuum by reason of its condition of open communication with the reception space 5 of the first-stage drier.

As already stated, a higher degree of vacuum is periodically established in the second-stage drier than that which normally obtains in the apparatus. Any convenient form of means may be employed for providing for this and for maintaining the respective degree of vacua. According to one convenient arrangement (illustrated in Figure 1), the vapour which forms in the first-stage drier is led off by a conduit 24 from the upper part of the reception space 5 of the drier to a condenser 25 interposed in the course of the vapours between the drier and a wet vacuum pump (not shown). This condenser may conveniently be a barometric contra-flow jet condenser in accordance with the arrangement shown in the drawings, although a surface condenser may if desired be employed, or any other suitable form of condenser for the purpose. The vapour which forms in the second-stage drier 9 is led off by way of a conduit 26 controlled by a valve 27 from the upper part of the drier to a second condenser 28 which may conveniently be of the surface type. The uncondensed vapour from this condenser is compressed into the first-mentioned condenser 25 by means of a steam jet pump 29, which operates as will be appreciated, to build up the degree of vacuum in the condenser 28 and therefore in the second-stage drier (after this has been isolated from the first-stage drier) to the higher degree of vacuum to btain in that drier during the completion of drying therein. For example, in the case where the material to be dried is damp grain, the operative vacuum obtaining in the driers while these are in open communication with one another could be say twenty-eight inches with a steam temperature of say 37.5° C., while the higher vacuum which is periodically built up in the second-stage drier would be, say, 29.4 inches. It will be understood, however, that these specific degrees of vacuum are mentioned purely by way of example, and that the actual vacua employed in the operation of the plant will depend upon a variety of factors, including for instance the nature and water content of the material to be dried and the steam temperature employed in the first-stage drier.

To enable the second-stage drier to be opened for the discharge of the fully dried and cooled material, the said drier is or may be provided with an air break cock.

Between the condenser 28 and the steam jet pump 29 is a vacuum valve 30, and a second vacuum valve 31 is provided controlling a passage 32 short-circuiting the jet pump. The second of these valves is opened and the first shut until the wet vacuum pump has built up, say, the 28 inches of vacuum in the driers, whereupon after closure of the valve 8 between the two driers, the second valve 31 is shut and the first 30 opened to enable the steam jet to build up the higher vacuum in the second-stage drier.

The two valves 8, 11 controlling respectively the delivery of the partially dried material from the first-stage drier to the second-stage drier and the fully dried and cooled material from the second-stage drier to the atmosphere, together with the two vacuum valves 30, 31 referred to, the valve 27, the air break cock and in the case of the arrangement according to Figure 2, the inlet and outlet valves 17 and 18 controlling respectively the inlet and outlet of the feed receiver 15, may conveniently be operated automatically and in timed sequence through the intermediary of hydraulic or like fluid-pressure operated actuating means and a timing gear designed to permit the cooling and discharge of the material from the apparatus intermittently in a predetermined time cycle in which the intermittent cooling and discharge is in timed correlation to the continuous feed of the material through the tubes of the first-stage drier.

Instead of employing a drier with vertically disposed tubes, the first-stage

drier of the plant may if desired comprise, as shown diagrammatically in Figure 4, a horizontally disposed system of tubes 33 through which steam circulates and which are spaced from one another so as to provide serpentine passages 34 between them down which the grain or the like is caused to gravitate at a controlled rate in contact with the heated walls of the tubes, for example, by means of an oscillating or revolving plate 35 similar in principle of operation to the oscillating or revolving plate 12 of the construction above described, and co-operating with spouts 36 terminating the lower end of an inner casing or lining 37 intervening between the tubes 33 and the walls of the drier and serving by reason of its corrugated sectional contour as shown, to guide the grain or the like as this descends the drier in close contact with the adjacent tubes 33. The spouts 36 serve, as will be appreciated, to assist in the passage of the grain or the like past the plate.

It will be understood, with further reference to the manner of operation of the plant, that while completion of the drying of the material is taking place under a higher vacuum in the second-stage drier, feed of the material through the first-stage drier continues and collection of the partially dried material from that drier takes place above the closed valve between the two driers in the collection hopper of the first-stage drier. This collection of partially dried material then descends into the second-stage drier upon opening of the valve between the two driers, whereafter the partially dried material from the first-stage drier flows uninterruptedly through the valve into the second-stage drier until the valve is again closed for the next operation of the second-stage drier.

It will be also understood that the invention is capable of considerable variation as regards constructional details and arrangement of parts of the plant. For example, the first and second-stage driers may be of any other convenient form than that described above, as also may the means for providing the requisite degrees of vacua in the driers and again the means for feeding the material to be dried into the vacuum system. Moreover, instead of employing steam as the heating medium for the driers, hot water or any other convenient heating medium may be employed, and either atmospheric or sub-atmospheric pressure may be employed in the event of steam being used.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A process of drying granular or powdered materials by heat treatment thereof in vacuo which consists in continuously feeding the material at a controlled rate along the interior of a heated first-stage vacuum drier and out of that drier into an unheated second-stage vacuum drier which during the normal course of the drying process is in open-communication with the first-stage drier and is therefore under the same degree of vacuum thereas, and while continuing the feed of the material along the interior of the first-stage drier, periodically cutting off communicating between the two driers and subjecting the partially dried material in the second-stage drier to a higher degree of vacuum than that to which it has been subjected in its passage through the first-stage drier and its discharge therefrom into the second-stage drier, until it has become completely dry and sufficiently cool to enable it to be discharged from the drier, whereupon it is discharged therefrom, the second-stage drier is again placed in open communication with the first-stage drier and progressively filled therefrom with a further batch of partially dried material, while, continuing the feed of material along the interior of the first-stage drier, this further batch of material upon completion of drying and cooling is discharged from the drier and the cycle of operations is continuously repeated so long as material is being fed along the first-stage drier.

2. A process as claimed in Claim 1, which further consists in preheating the material upon its introduction into the first-stage vacuum drier and before it has reached the heated zone thereof, by leading the vapours of the drying operation which is performed in this drier through the material and thence out of the drier to the source of vacuum.

3. Apparatus for carrying into effect the process claimed in Claim 1 or Claim 2, which comprises a first-stage vacuum drier having an inlet for the material to be dried and an outlet for the partially dried material; hermetic means for controlling the said inlet and the said outlet; means in the first-stage drier for effecting or regulating the passage of the material to be dried therethrough, at a controlled rate: an unheated second-stage vacuum drier communicating with the outlet of the first-stage drier and having an outlet for fully dried material; hermetic means for controlling the outlet of the second-stage drier, this means and the hermetic means first referred to being adapted to enable the two driers to be

placed into open communication with one another for the through passage of the partially dried material from the first-stage drier to the second-stage drier during the normal course of the drying process and then to be temporarily isolated from one another during the batchwise completion of drying and simultaneous cooling of the partially dried material in the second-stage drier; heating means in the first-stage drier for heating the material therein and vacuum producing means for exhausting the driers, the said vacuum producing means being adapted to maintain a higher degree of vacuum in the second-stage drier than in the first-stage drier and concomitantly therewith.

4. Apparatus as claimed in Claim 3, wherein the first-stage drier is a vertically disposed structure down which the material to be dried gravitates past the heating means to a collection hopper incorporated in the lower part of the drier and communicating by way of the outlet of the drier with the inlet of the second-stage drier.

5. Apparatus as claimed in Claim 4, wherein the heating means in the first-stage drier is located below an upper portion of the interior of the drier in which during the continuous feeding of the material into the drier a charge of material to be dried is accommodated en route for its passage past the heating means of the drier and the connection as between the interior of the drier and the vacuum producing means leads from the top of the said upper part of the interior of the drier whereby the vapours which are exhausted from the drier are caused to be drawn through the said charge of material so as to pre-heat the same.

6. Apparatus as claimed in any of the preceding Claims 3 to 5, wherein the means controlling the inlet of the first-stage drier embodies a vacuum feeding device for the material to be dried.

7. Apparatus as claimed in any of the preceding Claims 3 to 5, wherein the material to be dried is arranged to be fed to the first-stage drier from a primary supply hopper, the outlet of which communicates with the inlet of the drier through the intermediary of a vacuum lock constituting an intermediate hopper between the primary supply hopper and the drier and fitted with hermetically tight valves controlling on the one hand the outlet from the primary supply hopper and on the other the inlet of the drier whereby it may be placed in open communication with the primary supply hopper and isolated from the drier while it is being filled and *vice versa* while it is being emptied.

8. Apparatus as claimed in any of the preceding Claims 3 to 5, wherein means are provided for feeding the material to be dried into the vacuum system in a stream of water, the said means comprising a supply hopper for the material, into which the latter is arranged to be fed at atmospheric pressure along with sufficient water to enable it to be sucked from the hopper, a pump for sucking the mixture of material and water from the hopper and for delivering the same into a vacuum chamber situated at a level above that of the surface level of the material in the hopper, means in the vacuum chamber for removing surplus water from the material, a closed chute for conveyance by gravity of the de-watered material from the vacuum chamber into the first-stage drier via the inlet thereof and a discharge conduit for the separated water from the vacuum chamber constituting a barometric leg of a height in correspondence with the degree of vacuum to obtain in the vacuum chamber.

9. Apparatus as claimed in Claim 8, wherein the discharge conduit constituting the barometric leg delivers into the supply hopper wherein the water delivered from the conduit mixes with a further supply of material with which it is then recycled back to the vacuum chamber.

10. Apparatus as claimed in any of the preceding Claims 3 to 9, wherein the heating means in the first-stage drier comprises a number of tubes around which or through which steam or a like heating fluid is arranged to be circulated and through which or around which, as the case may be according to whether the steam is circulated around the tubes or through them, the material to be dried is caused slowly to gravitate on its way past the heating means.

11. Apparatus as claimed in Claim 10, wherein the tubes are vertically disposed and in order to control the rate of gravitation of the material past or through the tubes, an oscillating or revolving plate is disposed in a horizontal plane immediately below the bottom of the tubes or of the material-accommodating spaces therebetween.

12. Apparatus as claimed in Claim 10 or Claim 11, the arrangement being one in which the material to be dried gravitates through the tubes, wherein in order to ensure uniformity of treatment of the material through the columns thereof descending the tubes, each tube is fitted interiorly with a core member adapted to guide the individual grains or the like of the material first towards the heated surface of the surrounding tube and then away therefrom, thereby to ensure that an

approximately uniform average temperature shall obtain across the section of the descending column of material.

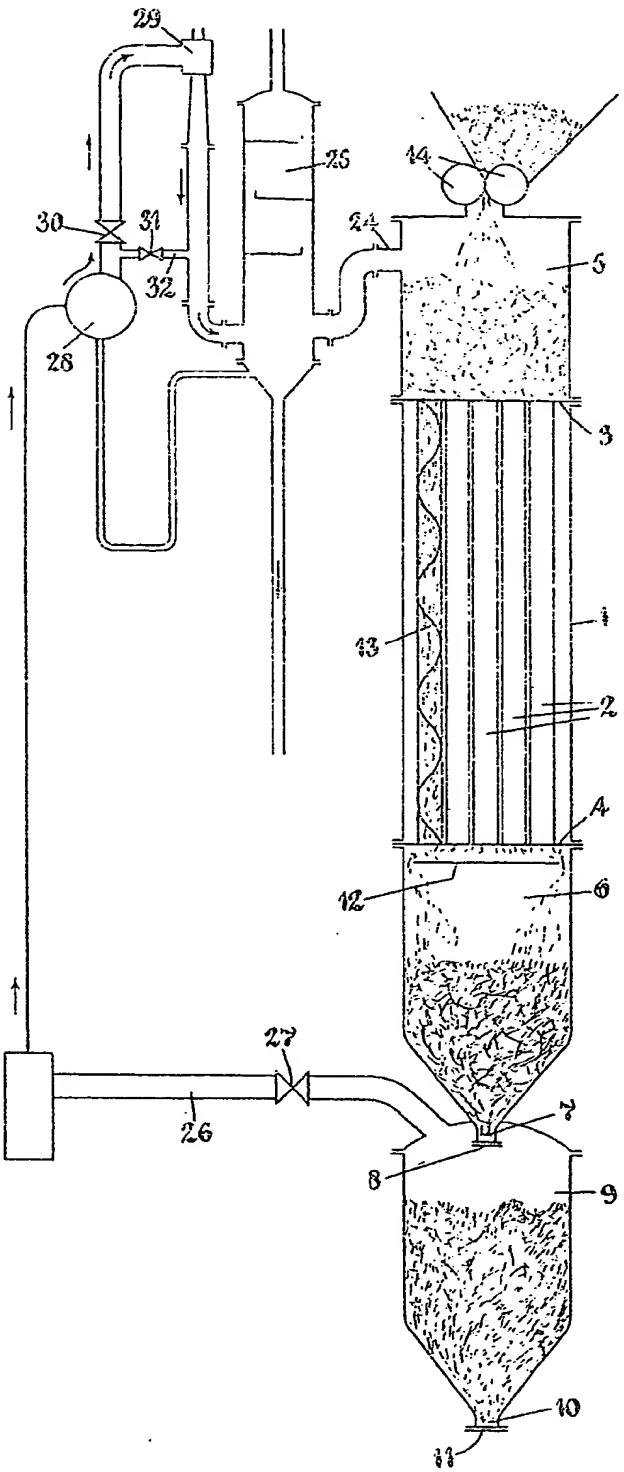
13. A process of drying granular or powdered materials by heat treatment thereof in vacuo, substantially as hereinbefore described with reference to the accompanying drawings.

14. Apparatus for drying granular or powdered materials by heat treatment thereof in vacuo, constructed, arranged and adapted to operate substantially as hereinbefore described with reference to the accompanying drawings.

Dated this 17th day of July, 1937.
G. F. REDFERN & CO.,
Chartered Patent Agents,
15, South Street, London, E.C.2,
Agents for the Applicants.

Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1938.

Fig. 1.



[This Drawing is a reproduction of the Original on a reduced scale.]

Fig. 2.

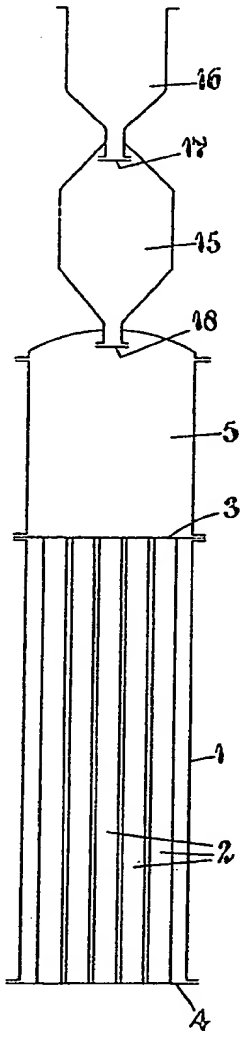


Fig. 3.

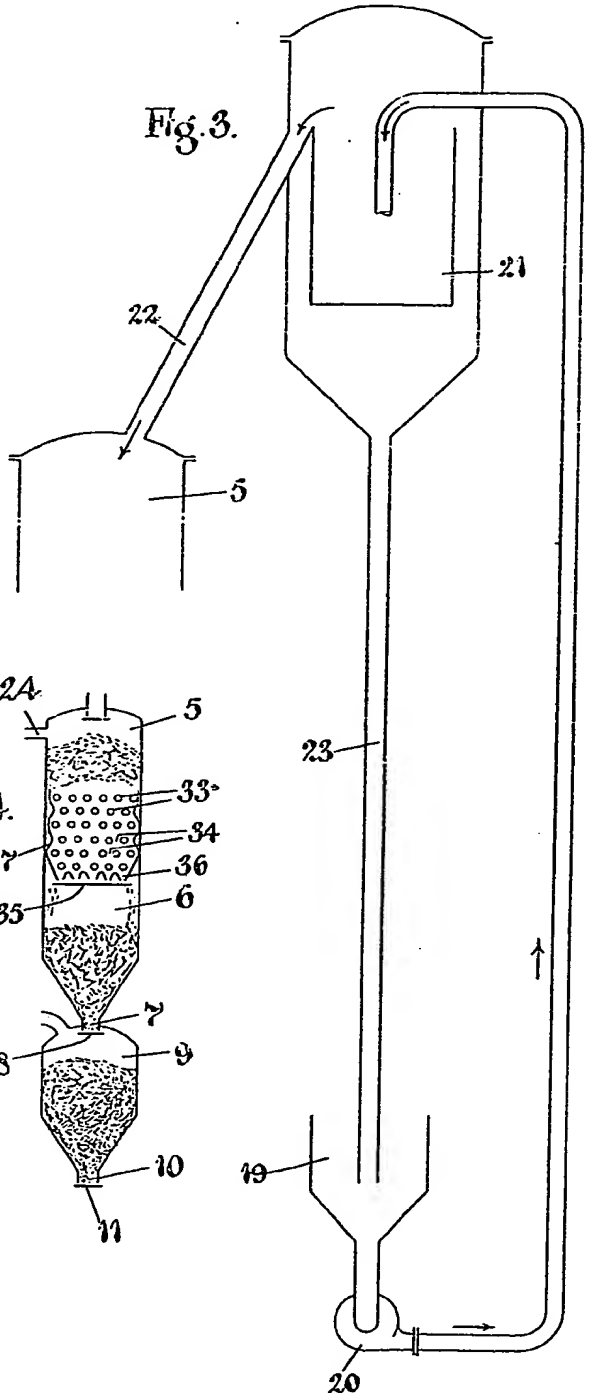


Fig. 4.

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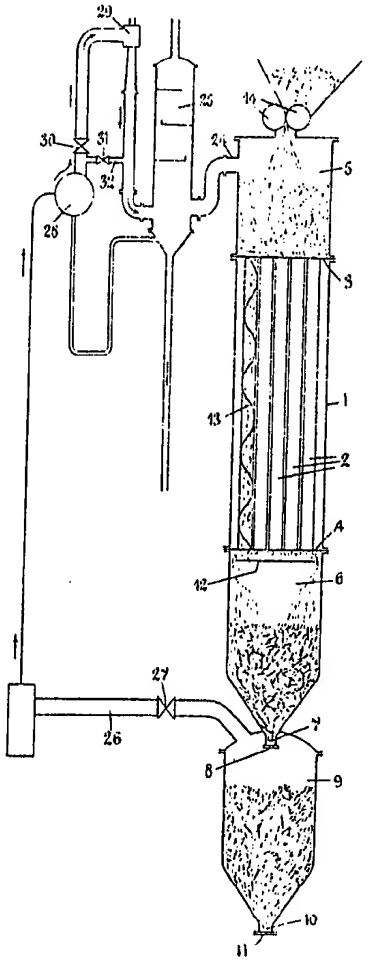
Fig.1.



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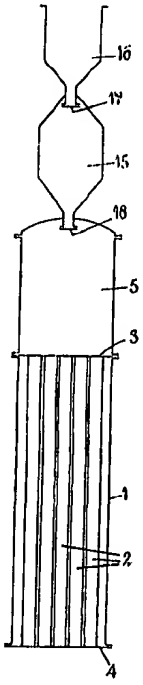

Fig.3.

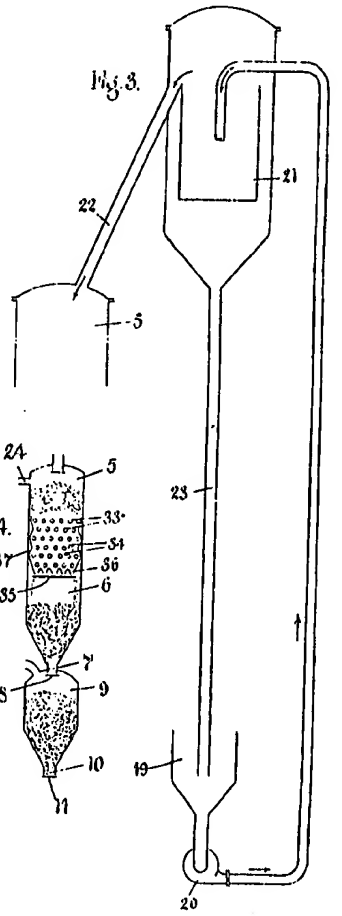

Fig.4.

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